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EMPIRICAL STUDY

Gesture and Vocabulary Learning in a Second Language

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When introducing new words in a second language (L2), presenting vocabulary with concurrent gestures might facilitate learners' recollection of new words. Previous research has suggested that this gestural advantage might hold only for gestures that overlap with the semantics of the words. Dual coding theory predicts that learners should learn input better when multiple sensory routes act as aids to retrieval. Our research replicated and extended previous studies examining the limits of gestures in learning L2 vocabulary. A within-participant design directly compared the effects of pairing low idiosyncratic gestures (gestures traditionally iconic with word meanings) versus high idiosyncratic gestures (gestures that likely need to be idiosyncratically paired with word meanings) with L2 vocabulary presentation, relative to using no gestures. Results supported dual coding theory: All gestures were helpful if they were not confusable with other to-be-learned words and if the number of words presented was limited.

Keywords gesture; lexical learning; Mandarin Chinese; dual coding theory; second language; vocabulary

Introduction

Several related bodies of research have demonstrated that gesture and language are tightly linked. Gesture predates and predicts the emergence of first language

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(L1) multiword oral production (e.g., Butcher & Goldin-Meadow, 2000; Iverson & Goldin-Meadow, 2005). Gestures used concurrently with oral language (co-speech gestures) appear to facilitate children's critical thinking (Kirk & Lewis, 2017), and the quality and frequency of gesture during verbal improvisation are associated with the quality and fluency of L1 verbal production (Lewis, Lovatt, & Kirk, 2015). Kelly (2001) suggested that the synergistic combination of speech and gestures may facilitate comprehension of complex language. Stevanoni and Salmon (2005) found that school-age children who had received instruction accompanied by gesture were better at recalling details verbally while retelling a story or an event than were children who had not received instruction accompanied by gesture. When gesturing is encouraged, L1 lexical retrieval is facilitated, and tip-of-the-tongue states are reduced in children (Pine, Bird, & Kirk, 2007) and in healthy and aphasic adults (Feyereisen, 2006). The emergence of iconic gestures (e.g., lifting the hand to the mouth to illustrate "drink") also coincides with the development of not only L1 oral production but also with second language (L2) oral production. (Mayberry & Nicolaidis, 2000)

In our study, we compared low idiosyncratic gestures to high idiosyncratic gestures to determine whether iconic gestures hold a privileged place in L2 vocabulary learning. We defined low idiosyncratic gestures as gestures that most people are likely to associate iconically with a verb meaning, for example, miming drinking from a glass to mean "drink." We defined high idiosyncratic gestures as gestures that bear no obvious initial semantic connection to a verb but which might be paired idiosyncratically with a verb, for example, clasped hands with interlocking fingers that might be associated with a meaning such as "please may I have a drink."

Gesture in L2 Vocabulary Learning

Given widely consistent results showing the facilitative nature of gesture in language generally and gesture in lexical production and retrieval in particular, it follows that gesture might facilitate vocabulary learning in L2 contexts as well. Indeed, researchers have been examining the contributions of gesture to L2 learning for some time (e.g., Gullberg, 2006; Macedonia & Klimesch, 2014; Macedonia & Knösche, 2011; Macedonia & von Kriegstein, 2012; Nicoladis, Pika, & Marentette, 2009; Quinn-Allen, 1995). Tellier (2008) examined L2 vocabulary memorization, comparing students' success rates at learning words introduced with gesture and words introduced with pictures (see also Asher, 1969). The results showed that words introduced with gesture were learned better than words introduced with pictures. Tellier interpreted

this result within the dual coding theory of Clark and Paivio (1991; see also Baddely, 1990; Moreno & Mayer, 2007; Paivio, 1986, 1990). Dual coding theory posits modality-specific generation and storage of mental representations. Given that auditory word presentation paired with either gestures or pictures represents an instance of dual modality coding, one prediction from the dual coding theory for Tellier's experiment was that pictures and gestures would have equivalent effects on word learning. However, Tellier found that L2 words studied with concurrent gestures were learned better than words studied with concurrent pictures. Furthermore, in an earlier study, Tellier (2007) also found that L2 learners had better recall of recently studied words when the learners also produced gestures compared to when they just observed the gestures being made by the instructor/experimenter (see also de Nooijer, van Gog, Paas, & Zwaan, 2013; Quinn-Allen, 1995; Rowe, Silverman, & Mullan, 2013). The performance boost attributed to co-speech gesture during learning is referred to as the enactment effect (cf. Macedonia, 2014; see also Krönke, Mueller, Friederici, & Obrig, 2013).

However, not all gestures appear to be created equal in eliciting the enactment effect. McNeill (1992) provided a widely cited taxonomy of gestures, including beat (i.e., representative of linguistic stress patterns), deictic (e.g., pointing), metaphoric (i.e., producing the same hand shape with both hands to represent the abstract concept of sameness; cf. Edwards, 2009), and iconic gestures. Church, Ayman-Nolley, and Mahootian (2004) further differentiated iconic gestures, that is, those which maintain a stable meaning across languages, from less stable but also representational gestures, which can be idiosyncratic between speakers even within the same language. We took this concept of representational gestures as multidimensional, defining the low idiosyncratic gestures as being more iconic, stable, and consistent across speakers and the high idiosyncratic gestures as being much more likely to vary in their associations across speakers. In other words, high idiosyncratic gestures are presumed to be meaningless for anyone other than the originator (or adopter) of the gesture, who may idiosyncratically associate it with a given meaning. For this reason, we have avoided the term meaningless because there is no way to ensure that a given participant cannot generate some meaning for a gesture and attach it to the associated lexical item.

Truly iconic (i.e., low idiosyncratic) gestures have been most widely studied in connection with language production (Nicoladis, 2007), perhaps due to their rather straightforward connection to concrete conceptual representations, that is, within the context of embodied cognition (Barsalou, 2003). For example, iconic gestures have been observed to be produced more often by people

experiencing tip-of-the-tongue states (Frick-Horbury & Guttenburg, 1998). Iconic gestures also seem to facilitate longer, more complex utterances by children in their native languages (Nicoladis, 2002; Nicoladis, Mayberry, & Genesee, 1999).

Other gesture types have been studied much less extensively in connection with language production and learning (Nicoladis, 2007), perhaps because the relation between iconic gestures and embodied representations is so obvious. Nevertheless, Nicoladis discussed the possibility that simply moving the hands may aid somehow in lexical access (see Macedonia, 2014, for a summary of hypotheses about the source of the enactment effect, including depth of encoding, mental imagery, and kinetic imagery, none of which appears to be mutually exclusive). Consistent with this speculation, Novack and Goldin-Meadow (2017) proposed a theory of gesture that explicitly differentiates gesture mechanism from gesture function. Novack and Goldin-Meadow argued that, even if gesture is fundamentally connected to simulated action in terms of its mechanism, its function cannot be reduced to simulated action or the iconic embodiment of mental representations. In other words, just moving the hands might be sufficient to connect words or concepts to gestures on a representational level (i.e., on a semantic level), in line with Clark and Paivio's (1991) dual coding theory.

Partially consistent with this moving-the-hands view of gesture, the study by So, Sim, and Low (2012) compared the effects of pairing L2 words with iconic gestures versus pairing them with mnemonic (or beat) gestures for both adults and children learning L2 words. So et al. observed that both the iconic (meaningful) and beat (meaningless) gestures improved L2 vocabulary learning by their adult participants. However, only the iconic gestures aided their child participants in learning L2 vocabulary. The authors concluded that any gesture could become semantically meaningful if the learner is metacognitively (or metalinguistically) sophisticated enough to attach meaning to it. Macedonia and Klimesch (2014) also provided data that were at least partially consistent with this view. In their study, they found that arbitrary gestures were effective at improving L2 lexical recall when paired with abstract words (see also Macedonia, 2003). These findings are important because abstract words represent a significant portion of the lexicon of any language; and if only iconic gestures facilitate L2 vocabulary learning, then the use of gesture in L2 instruction would be limited.

In more direct opposition to Novack and Goldin-Meadow's (2017) assertion that the efficacy of gesture in aiding L2 vocabulary learning might be attributed to just moving the hands, Macedonia, Müller, and Friederici (2011; see also Macedonia, Muller, & Friederici, 2010) performed a functional magnetic

resonance imaging (fMRI) experiment examining the brain activity associated with iconic and meaningless gestures presented during a 4-day training session in which German speakers learned 92 concrete nouns in an artificial language that the authors called Vimmi. Although brain activity was observed to differ in the fMRI portion of the experiment, more relevant here are Macedonia et al.'s behavioral results. Participants' recognition memory for the new vocabulary and their ability to translate from German to Vimmi and from Vimmi to German were better when words were presented concurrently with iconic gestures. The authors concluded that "gestures must be iconic to support memory for concrete nouns" (p. 991).

Kelly, Hirata, Manansala, and Huang (2014) also presented data suggesting that just moving the hands fails to support novel vocabulary learning, at least when the gestures are tied to low-level phonemic properties of the novel words. Participants in this study studied Japanese vocabulary either paired or not with gestures that corresponded to either syllable structure or mora structure. The main finding was that all participants performed equivalently on later identification and vocabulary tests, suggesting that gesture had no influence on learning.

It remains an open question, then, whether iconicity is required to map gestures to novel L2 words in support of vocabulary learning or even near-term recognition. In the experiment reported here, we focused on the two types of representational co-speech gestures introduced above: iconic and arbitrary—termed meaningless by Macedonia et al. (2011). As noted, however, we labeled these gestures as low idiosyncratic and high idiosyncratic, respectively, to reflect the gradation that we propose to be inherent in the semantic mapping of gestures to words. We did so as a partial replication of a combined behavioral and event-related potential study by Kelly, McDevitt, and Esch (2009). Importantly, in a manner different from nearly every previous study of gesture and L2 vocabulary learning, Kelly et al. presented all the items in a within-subjects design to avoid concerns that previous results suggesting the benefits of gesture might have been due to uncontrolled between-group effects. In their behavioral experiment, Kelly et al. compared the learning and subsequent recall (5 minutes, 2 days, and 1 week after instruction) of L2 Japanese verbs presented with congruent iconic gestures, with incongruent iconic gestures (which were iconic with other verbs in the set), and with no gesture. Kelly et al. found that the congruent-iconic-gesture condition facilitated recall better than both the incongruent-iconic-gesture and the no-gesture conditions. Their second experiment, which included event-related potentials, revealed a significant difference in the late positive component between L2 words learned with concurrent

congruent iconic gestures and those learned without gestures. Kelly et al. took this pattern of results as evidence supporting the hypothesis that gestures improve or aid recall of lexical items rather than simply increase the familiarity of those items. Additionally, and critically for our experiment, the failure of incongruent iconic gestures to improve L2 word recall in the behavioral experiment was interpreted by Kelly et al. as evidence that gestures do not simply draw more attention to words that are being studied. Instead, they contended that iconic gestures nonarbitrarily represent the meanings of newly acquired words, pairing established semantic concepts with new lexical representations (cf. Macedonia et al., 2011; Macedonia & Klimesch, 2014). The failure of the incongruent iconic gestures to have the same effect suggested that, when established iconic gestures are paired with new lexical items that bear different semantic features, this clash in semantics hinders, or at least fails to support, learning.

As discussed previously, however, the dual coding theory (Paivio, 1986, 1990), as well as some prior experimental results, have suggested that there is no obvious reason why strict iconicity between gesture and word should be required. So et al.'s (2012) conclusions also questioned why it would be necessary for strict iconicity to be required as long as the learner can attach some meaning—semantic or mnemonic—to the gesture. In Kelly et al.'s (2009) experiment, however, congruent iconic gestures that were matched to the meanings of the verbs were compared to iconic gestures for other verbs in the set of materials to create the incongruent-iconic-gesture condition. Thus, for some participants, the iconic gesture for, say, "drink" was paired with the Japanese verb *nomu* ("drink"), and the gesture for, say, "hammer" was paired with the Japanese verb *tataku* ("hammer"). For other participants, however, the gestures for these two verbs were reversed. Given the close iconicity of the gestures used by Kelly et al., it is no wonder that incongruous iconic gestures proved to be unhelpful in learning the L2 Japanese verbs; they were easily identifiable with their meaning and, therefore, easily confusable. Prompting participants to pair words with gestures was in essence a paired-associates task. Furthermore, prompting them to pair a gesture that is typically associated with another word in the list (via iconicity) introduced a classic interference effect (Keppel, 1968). No error analyses were presented, so the number of errors in the incongruent-gesture condition due to misidentifying, for example, *nomu* as "hammer" and "hammer" as *nomu* is not known, but such errors were likely common.

We wished to extend the intriguing findings of Kelly et al.'s (2009) experiment by examining the utility of high idiosyncratic gestures in L2 lexical recall. We hypothesized that gestures that were not obviously related to the meanings of novel L2 words would nevertheless likely be associated idiosyncratically

with the L2 words. To test this hypothesis, we conducted an experiment similar to Kelly et al.'s in most ways but differing from it in one crucial respect. Specifically, we presented L2 verbs paired with either low idiosyncratic (iconic) gestures, no gestures, or high idiosyncratic gestures that could not easily be associated with other words in the stimulus set yet could be idiosyncratically paired with target words. As we noted previously, we termed these gestures high idiosyncratic rather than meaningless because we could not prevent participants from generating some meaning for them. However, any meanings, if generated, would be idiosyncratic across participants. Both the low idiosyncratic and high idiosyncratic gestures, then, could qualify as representational (Church et al., 2004). If, as suggested by Kelly et al.'s results, congruent iconic gestures are most effectively paired nonarbitrarily with new L2 words, then the low idiosyncratic condition should result in better L2 verb learning than both the high idiosyncratic and the no-gesture conditions. However, if the association of any gesture with a new L2 word during learning facilitates later recall—even if that association were purely idiosyncratic—then the two gesture conditions should both result in better learning than would the no-gesture condition.

Experiment

Following Kelly et al. (2009), we conducted a within-participants experiment comparing the learning of L2 Mandarin Chinese words. The choice of Mandarin was made because it is the native language of the first author, so presentation and testing could be performed with a native accent. Furthermore, replication, or lack thereof, should be established across languages rather than exclusively within a single language. There were three conditions: words presented with no gestures, with low idiosyncratic gestures, and with high idiosyncratic gestures. Again, it is this third condition that differed from Kelly et al.'s design. Dual coding theory (Clark & Paivio, 1991; Paivio, 1986, 1990) predicts that in the absence of interference between items, pairing new L2 words with any gesture should facilitate learning. This pattern of results, if observed, would be consistent with the event-related potentials experiment of Kelly et al. The heightened late positive component signal that Kelly et al. obtained was interpreted as showing a recall advantage for words paired with gestures. They failed to obtain any difference in the N400 component between conditions, however. Because the N400 component is associated with semantic representations, Kelly et al. concluded that the addition of gesture did not improve the quality of the semantic representation of the words. Rather, the pairing of the gesture and word provided dual-mode routes to recall. In our design, the high idiosyncratic gesture should have either no effect or a deleterious effect on

semantic representation if strict iconicity is required to associate gestures with words. But the high idiosyncratic gesture should facilitate recall according to the dual coding theory. We contend that a classic interference effect (Keppel, 1968) was the reason that Kelly et al. failed to observe any benefit from their incongruous-gesture condition.

Method

Participants

Thirty participants (25 females; $M_{age} = 24.07$ years, *range* = 18–53 years) from the University of Illinois at Urbana-Champaign community participated for course credit or $5. All participants were either native speakers of Midwestern American English or speakers who considered American English to be their L1 and had no prior experience with Mandarin Chinese or any other variety of Chinese. However, of the 30 participants, only seven reported that they had no L2 experience. Among the remaining 23 participants, there was a wide range of language experience, from 1 to 3 years of high school Spanish up to 21 years of Malayalam. As such, approximately one-third of the participants considered themselves to be bilingual (Spanish, Arabic, Malayalam, Thai, and Lao). On the whole, therefore, the participants represented a relatively linguistically experienced sample.

Materials and Procedure

We conducted multiple group sessions, with at least two participants in each session. The materials contained 18 one-syllable Chinese words (14 verbs, two adjectives, one noun, and one adverb; all materials are listed in Appendix S1 in the Supporting Information online). We organized study sessions in which the first six words for the first 10 participants were in the no-gesture condition, the second six words were in the high-idiosyncratic-gesture condition, and the third six words were in the low-idiosyncratic-gesture condition. We systematically rotated this order (and the words in each condition) for the next 10 participants so that all items appeared once across all three groups of participants in each of the gesture conditions and equally often in the first, second, and third set of items. The design was thus fully within-participants and within-items. High idiosyncratic gestures were developed so that they were not obviously iconic with any other word in or outside of the set of materials. For example, one of the high idiosyncratic gestures consisted of extending the little finger off to the side of an otherwise closed fist (see Appendix S1).

After participants had provided informed consent, the first author (L1 Mandarin Chinese speaker) read instructions and provided one example in

each of the gesture conditions. Participants were told that at the end of the session there would be a vocabulary test. After allowing participants a chance to ask questions, the experimenter repeated each word two times along with its English translation, with participants repeating both the Chinese word and its translation each time. Participants did not produce any gestures during their repetitions. The experimenter did not prohibit them from producing gestures but simply told them, "Watch me and repeat after me." We adopted this procedure so that the data would be as comparable as possible to those of Kelly et al. (2009), who also did not ask participants to copy the gestures.

After all 18 words had been introduced, there was a 2-minute break, and the words were presented again in the same order and same conditions. Next, we gave participants a 5-minute break, during which they filled out a brief demographic and language background survey. This was done both to double-check that they had no previous experience with Chinese and to disrupt any possible attempts at continuous silent rehearsal of the words. After this break, we administered a multiple-choice test of all 18 previously presented words. The experimenter presented the words aurally to the participants with gestures. The presentation order was pseudorandomized (as described above), and the order of items in the test was randomized across experimental sessions. Participants circled one English translation for each word from a choice of four English translations. The three foils in each item consisted of two other words from the 18 items that had been presented and of one that had not been presented. The distractors (of both types) were rotated equally across test items. Each session lasted no longer than 60 minutes.

Data Analysis

We built logit mixed-effects models (Jaeger, 2008) in R (R Core Team, 2017) using the lmerTest package (Kuznetsova, Brockhoff, & Christensen, 2017) to analyze the binomial accuracy data (0 = "incorrect," 1 = "correct," maximum score = 18) to account for participant and item variability in the data. We chose the maximal random-effect structure that converged for the binary data (Barr, Levy, Scheepers, & Tily, 2013), and the converged maximal random-effect structure included random intercepts for participants and items and the random slope of gesture condition for participants. A model including the random slope of gesture for item did not converge. To ensure that a subset of items was not driving our effects, we performed a series of pairwise *t* tests for each item, comparing the arbitrary and iconic conditions. None of these tests showed a significant difference within any item. We used contrast coding for the fixed effect of the gesture condition with the no-gesture condition as the

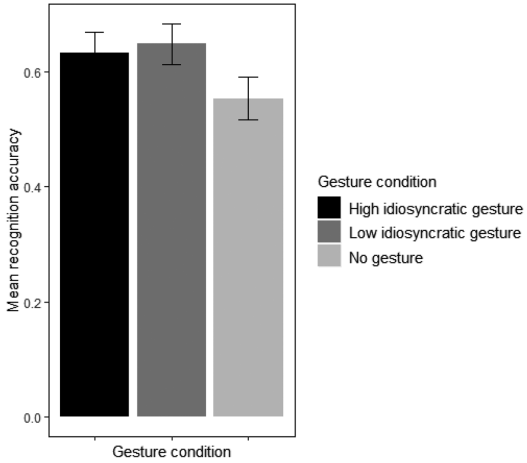

Figure 1 Participants' accuracy in identifying English translations of Chinese words on a recognition test. Error bars represent 95% confidence intervals.

reference level. We added item order to the analysis (cf. Christianson, Mestre, & Luke, 2012) to identify potential interference effects as well as to determine whether any observed interference effects varied as a function of gesture condition.

Results

Recognition Accuracy[1]

Logit mixed-effects model results revealed that the low idiosyncratic gesture and high idiosyncratic gesture conditions did not significantly differ from each other (low idiosyncratic condition: $M = 0.65$, $SD = 0.48$; high idiosyncratic condition: $M = 0.63$, $SD = 0.48$; no-gesture condition: $M = 0.55$, $SD = 0.50$). However, both the low idiosyncratic and high idiosyncratic conditions differed significantly from the no-gesture condition ($ps < .05$). Both gesture conditions led to more accurate recall than the no-gesture condition as is illustrated in Figure 1. No interaction terms were significant in any models so they were removed from the final model. The model output is provided in Table 1.

Trial Order

As the trial order increased, recognition accuracy decreased irrespective of gesture condition ($p < .001$). Participants became less accurate as the experimental session progressed. Figure 2 illustrates that this was likely due to proactive interference from the words that were introduced earlier (Keppel, 1968). The

Table 1 Coefficient estimates from a generalized linear mixed-effects model for binomial recognition accuracy data

	Fixed effects				Random effects variance	
Predictor	Coefficient	*SE*	*z*	*p* (>|*z*|)	By subject	By item
Intercept	1.11	0.38	2.90	< .01	0.45	1.04
Low idiosyncratic gesture	0.80	0.27	2.97	< .01	0.06	
High idiosyncratic gesture	0.65	0.27	2.37	.02	0.18	
Trial order	–0.10	0.03	–4.03	< .001		

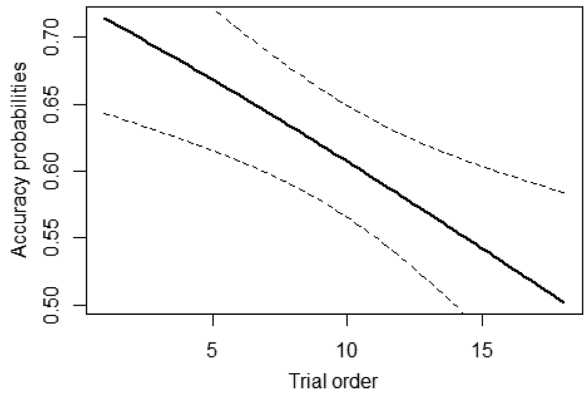

Figure 2 Predicted recognition accuracy probabilities by trial order. Dotted lines indicate 95% confidence intervals for the predicted accuracy probabilities.

lack of interaction with gesture condition suggests that gestures did not reduce interference as new words were introduced.

Discussion

The results of our experiment show an 8% to 10% advantage in L2 lexical recognition for words that were presented concurrently with gestures compared to words that were presented without gestures. Previous research by Kelly et al. (2009) had shown that iconic gestures that were matched incongruently with the meanings of L2 words failed to facilitate learning of the L2 words with which they were paired. We hypothesized that this was likely because the incongruent matching paired them with already established meanings, creating semantic

interference. Our study extended these previous findings and supported our hypothesis by showing that, even when gestures were designed to be more idiosyncratically related to speech—leaving it to the participants to create associations of the semantics of the gesture to the semantics of the word, recognition was facilitated. In other words, our results suggest that gestures do not need to be obviously iconic to facilitate L2 lexical recognition; they can apparently consist of any arbitrary, yet unique, hand movement that does not call to mind any other iconic gesture that might interfere with the pairing of the gesture and word in memory.

There are two possible explanations for this pattern of results, which are not necessarily mutually exclusive. It might be that there is something uniquely helpful about just moving the hands (Nicoladis, 2007), that is, an enactment effect (Macedonia, 2014). However, our participants did not move their hands; they only watched the experimenter move her hands. Perhaps learners create an "internal kinetic image" (Macedonia, 2014, p. 3) of words by gesturing (cf. Hostetter & Alibali, 2008). If so, the participants in our experiment must have been able to do so without moving their hands themselves. Krönke et al. (2013) observed behavioral results similar to ours in that implicit recall of L2 words was equivalent in conditions in which participants performed gestures or just observed gestures (see also de Nooijer et al., 2013); Krönke et al.'s fMRI results differed for the two groups, however.

Another possibility—a possibility that is hinted at by our use of the terms low idiosyncratic and high idiosyncratic—is that our participants generated idiosyncratic, mnemonic, ad hoc iconic associations between the arbitrary gestures and the lexical items with which they were paired. Given that participants were, on average, relatively experienced L2 learners, it seems likely that they were metalinguistically savvy enough to apply this strategy, similar to the adult participants in So et al.'s research (2012). The point is that generating associations between L2 words and gestures—either using iconic gestures or perhaps novel iconic gestures—aids L2 lexical learning. The facilitative effects of combining gesture with L2 words do fade, however, as more words are introduced. This proactive interference effect on words introduced later is not ameliorated by adding either iconic or arbitrary gestures to the words.

The results of our study are largely consistent with previous research showing that iconic gestures facilitate L2 vocabulary learning. Our data extend and elaborate on the previous literature in several ways, however. First, the finding that high idiosyncratic gestures (i.e., noniconic gestures that can be idiosyncratically semantically associated with new words) can facilitate L2 lexical recognition as effectively as low idiosyncratic gestures (i.e., gestures that are

highly iconic with established semantic meanings) adds to previous results (e.g., Kelly et al., 2009; Macedonia et al., 2011, 2014; So et al., 2012). This finding is important for pedagogical reasons because large numbers of words in any language are not easily captured by iconic gestures. L2 instructors can pair relatively arbitrary gestures with new L2 vocabulary and still facilitate learning as long as the gesture is not obviously iconic with some other known word (and thus interferential).

Second, our results dovetail with those of Tellier (2007, 2008) in several ways. In her 2007 study, Tellier reported that learners who had both repeated the L2 lexical items and reproduced the gestures displayed better learning than learners who had simply watched the gestures and repeated the words orally. Our participants did not reproduce the gestures, yet they still gained an advantage in lexical recall of approximately 10%. An incremental improvement (i.e., auditory < auditory + visual < auditory + visual + kinetic/motor-manual) is predicted by the dual coding theory (Clark & Paivio, 1991; Paivio, 1986, 1990), which states that an increase in coding routes should result in better learning and multiple access routes for recall. Tellier's 2008 study found that watching gestures during L2 lexical study improved recall more than viewing pictures of the presented words. Given that viewing gestures while hearing and repeating words and viewing pictures while hearing and repeating words seem at first blush to both entail the use of two sensory coding routes (auditory and visual), the difference between picture and gesture conditions might seem unexpected under the dual coding theory. However, it might well be that watching someone produce a gesture, especially in a focused training context, triggers a mental simulation of that gesture, perhaps somewhere in the motor cortex, that is, an implicit enactment effect. It is far beyond the scope of the current study to speculate about the role of mirror neurons or even whether or not they exist (see Gallese, Gernsbacher, Heyes, Hickok, & Iacoboni, 2011, for a lively discussion of these topics). Nevertheless, it is reasonable to speculate that visually processing kinetic movement could generate some sort of implicit enactment effect that could plausibly constitute an additional sensory coding route beyond the auditory and visual routes involved in processing a static picture.

A further important inference can be drawn by considering the present results and those of Tellier (2007) together. Given that just watching gestures being produced during L2 vocabulary study improved recall more than looking at pictures during study, it does not seem likely that our results can be wholly attributed to an ad hoc mnemonic strategy applied to the high idiosyncratic gestures used here because this same strategy could presumably have been

applied by Tellier's adult participants to the pictures used in that study. Nor does it seem likely that moving the hands is required for gestures to facilitate L2 vocabulary learning, given that our participants did not move their hands. Rather, it seems likely that both the multimodal encoding discussed above and the application of some idiosyncratic, mnemonic associative strategy affect learning when gestures—especially highly idiosyncratic gestures—are paired with L2 words.

Finally, our study is the first in the gesture literature, to our knowledge, to analyze the order of presentation of the items to examine temporal or linear influences on recognition or recollection. Interestingly, the results of this analysis revealed that proactive interference accrued as more words were introduced. This trial order effect did not interact with gesture condition, suggesting that new L2 lexical items should be introduced in relatively small numbers at any given time, whether or not they are accompanied by gestures. Some previous studies trained participants on much larger numbers of words than we did here, and for extended periods of time. For example, Macedonia et al. (2011) trained their participants on 92 words in an artificial language over 4 days. It is possible that any facilitative effects of their meaningless (i.e., arbitrary or high idiosyncratic) gestures washed out over multiple presentations as participants focused on more meaningful gestures that were more easily paired in memory with their lexical items (and thus were perhaps also more resilient to interference). More research is necessary to determine if this speculation is justified. In any case, in most classroom situations, small groups of words are introduced at a single time, and our results suggest that this type of context would be ideal for including gestures.

Conclusion

In sum, consistent with our initial hypothesis, our findings show that gestures facilitate and enhance L2 word recognition, irrespective of the iconicity of the gestures. Instructing with gestures visually conveys to learners information about the words or concepts (McNeill, 1992). During learning, gestures may develop stronger memory traces of the information and cause better recognition compared to learning without any gesture (Kelly et al., 2009), as predicted by dual coding theory. These findings are consistent with previous research (e.g., Allen, 2000; Church et al., 2004; Goldin-Meadow, Kim, & Singer, 1999; Quinn-Allen, 1995), which has found that gestures enhance classroom learning and are beneficial to education in general. Especially for L2 learners, this strategy may provide learners with representational scaffolding as they encounter and learn new words in the L2 (Church et al., 2004; Macedonia, 2014).

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Note

1 Throughout this study, and especially in reporting and discussing the results, we have used the terms recognition and learning relatively interchangeably. Of course, we did not intend to imply that our participants learned the Chinese words in the experiment in any meaningful or long-lasting way. It is well beyond the scope of this study to speculate on what, if anything, they did learn about the words, especially given that linguists do not even agree on what L1 speakers know about a word when they know a word. We refer interested readers to Gullberg, Roberts, and Dimroth (2012) for a discussion of what learners might be able to learn about L2 words after brief exposure. For our purposes, we meant only participants' ability to choose the correct English translation in the described multiple-choice task, whatever level of learning that may represent. We take recognition accuracy of this sort to be a necessary first step toward learning any L2 lexical items, however.

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Supporting Information

Additional Supporting Information may be found in the online version of this article at the publisher's website:

Appendix S1. Study Materials.

Appendix: Accessible Summary (also publicly available at https://oasis-database.org)

Gesture and Vocabulary Learning in a Second Language

What This Research Was About and Why It Is Important

When teaching vocabulary in a second language, teachers often introduce new words by pairing them with gestures, and there is considerable research showing that this helps learners remember new words. However, it is not well understood which *kind* of gestures help word learning. For example, gestures that closely illustrate the meaning of a word (such as gesturing drinking from a cup while introducing the word for "drink") may be more useful for learning words, compared to gestures that are novel or do not illustrate the meaning of a word well. In this study, the researchers compared the effectiveness of different types of gestures when presenting Mandarin Chinese words orally to native English speakers with no prior experience with Chinese.

What the Researchers Did

- The researchers paired spoken Mandarin Chinese words (such as "good" or "knock") with seeing two types of gestures:
    - iconic (illustrative or low idiosyncratic) gestures (e.g., seeing a thumb up while hearing the word for "good"),
    - arbitrary (high idiosyncratic) gestures (e.g., seeing a little finger raised while hearing the word for "good").
- There were 30 participants (university students and university employees) with no knowledge of Mandarin Chinese.

- The participants were asked to "watch and listen" as a native Chinese speaker introduced 18 new words. Each word was presented in one of three ways, as follows:
    - six words with an iconic (low idiosyncratic) gesture,
    - six words with an arbitrary (high idiosyncratic) gesture,
    - and six words with no gesture.
- Participants went through the list of words twice (back to back, in the same session).
- Immediately after, they took a multiple-choice test on the words. They heard a word presented with a gesture and selected the word's meaning in English from four alternatives.
- The researchers analyzed the accuracy of selecting the correct meaning according to whether presentation had been with an iconic (low idiosyncratic) gesture, an arbitrary (high idiosyncratic) gesture, or no gesture.

What the Researchers Found

- The participants' accuracy on the test was about 10% higher for the Mandarin Chinese words introduced with either an iconic (low idiosyncratic) gesture or with an arbitrary (high idiosyncratic) gesture, compared to the words presented with no gesture.
- There were no reliable differences between the effects of low idiosyncratic versus high idiosyncratic gestures.
- The participants' performance on the test generally declined as the test progressed. The gesture advantage faded beyond about the first 10 presented words.
- This fading effect was likely due to participants' having to retrieve the meanings of multiple newly learned words on the test, and keeping the meanings of these new words apart became difficult as the test progressed.

Things to Consider

- Pairing vocabulary with gestures promoted recognition of, and perhaps eventual learning of, new words heard in a second language.
- Gestures might help learners remember words they have heard because gestures strengthen links between words and meanings.
- In this study, the participants did not perform gestures themselves as they heard new Mandarin Chinese words; they only saw gestures shown to them.

It is possible that repeating or performing gestures yourself—when hearing or maybe also seeing new words—might provide extra benefits.
- Teachers should use gesture as part of oral vocabulary instruction; however, new words should be introduced in small batches to avoid interference.

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